FURTHER DEVELOPMENTS IN OVARIOTOMIZED FOWL.

H. D. GOODALE,

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION.

In several castrated Brown Leghorn females certain developments of particular interest have taken place. These developments relate not only to the plumage and other external characters but also to certain structures associated with the reproductive organs. In brief, these individuals developed male plumage and other male characters. After a time, however, certain changes in the plumage of some individuals took place, best described as a change to or toward the female type, as the case might be. Still later, the plumage changed again to or towards the male type. Usually, the development of female plumage in poullards is to be referred to a regeneration of the ovary but an examination showed that no regeneration had occurred in these individuals but that instead an organ *sui generis* had grown. A portion of the organ has been removed from each bird and sectioned. Its structure clearly is neither that of the ovary nor that of the testes. The exact nature of these organs cannot be determined at present, although their structure suggests that they have some relation to the epididymis. On the right side in normal females, both ducks and fowl, a bit of tissue is sometimes found on the spot corresponding to the site of the ovary on the other side. From this body a strand can sometimes be traced posteriorly. While this body has some resemblances histologically to that of the organs developed in the castrated females, it is impossible to assert that the latter results from the hypertrophy of the former, even though there are many other reasons for drawing this conclusion. To demonstrate the assumed relationship between the structures will require a considerable series of stages which are not at present available and whose collection will require some time.

The history of these cases may now be considered in detail.

The first is that of the pullet described in the *American Naturalist*, Volume XLVII., 1913. The chick had been completely castrated when three weeks of age. In due course of time, the bird developed a good male's plumage with large comb and spurs. However, there were a number of feathers in the dorsal region which were shaped and stippled like those of the hen but rather different in color. (Fig. 3, *b*, *American Naturalist.*) With the coming of the moult it was found that the new feathers were essentially like the old. That is, the plumage retained its intermediate character. The bird was then killed and dissected. The conditions found were so remarkable that it was thought best to await confirmatory data before publishing. On either side, at the level of the adrenals was an organ which had the appearance of a small testis, though divided into several lobes. Histologically, however, it was very different. Leading posteriorly from each of these structures to the cloaca was a yellowish white strand (cord, duct) resembling an immature vas deferens. The *left oviduct* in an infantile condition was present.

The presence of the bodies described for 1196 appears to be more usual in ovariotomized fowl because such organs, with one possible exception, have not been found among the eight or ten ovariotomized ducks that have been opened or autopsied at various times, though found in all fowl thus far examined. Both species have ranged from a few months to three years of age, all but one at least a year old. Evidently the possibility of the development of the bodies in question rests upon some genetic basis. Nor are they necessary for the assumption of male characters by the ovariotomized female, since the ducks have developed as good male plumage as the fowl.

Perhaps the question will be raised regarding the possibility that all these individuals were really males. It is desirable to consider this phase of the matter in some detail. There are two general possibilities of error—first, a possibility that an error was made in identifying the sex of the individual at the time of the operation; an error however, that would be equivalent to one made in identifying the sexes of domestic poultry by their plumage. The gonads of the male and female are quite unlike, even before hatching time (cf. Thompson, *Arch. Ent.*,

1911). The *single* ovary is a flat sheet of tissue, roughly triangular in outline, found on the left side only. The *two* testes are each cigar-shaped.

The second possibility is that a clerical error was made. It should be needless to say that great care is taken to avoid this sort of mistake. However, there are several checks on mistakes of either sort. First, in ovariotomy an incision is made on the left side only, never on the right. In the extremely rare event of there being an ovary on the right side its presence would remain unknown until much later. The right side is never examined at the time of operation. Therefore, if a supposed female were really a male, the presence of the right testis would bring the mistake to light in due course of time. Second, an infantile oviduct has always been found in the cases autopsied. These oviducts are not a vague strand of tissue but on the contrary are in about the same condition as a four or five month pullet's before the ovary has begun to enlarge preparatory to laying. Third, there are a number of peculiarities about the castrated females that differentiate them from males both normal and castrated. These are fully considered in another place.[1] Finally, it may be noted that the number of instances on record is fairly large. During the past year a flock of fifteen ovariotomized ducks, besides several ovariotomized fowl, have been maintained at this station.

The second individual for consideration is a rose-combed bird of a different strain of Brown Leghorns which was castrated as a four-weeks-old chick in 1914. This bird, number 3840, developed a beautiful male plumage in due course of time, except that for some reason the development of the tail was imperfect. The main tail feathers were present but had an injured appearance. Number 1196, described above, likewise had the dorsal portion of the uropygium missing, which gave her a bob-tailed appearance. Number 3840 also had the same bob-tailed appearance in 1914, though the feathers were actually present, but lost it with the new feathers in the autumn of 1915. The comb and wattles developed more slowly than those of the normal male, but by late spring they had become large and male-like. The spurs

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also were fully developed. When the bird moulted (1915) the new feathers were those of the *female* throughout. As is frequently the case, the bird moulted piece-meal, both kinds of feathers co-existing at one time. Gradually, however, the male feathers were replaced by feathers that could not be distinguished from those of the female. When it is recalled that the Brown Leghorns are practically identical in color with the Jungle fowl, the change can readily be appreciated. The bird was not killed as it was desired to keep her for further observation, but instead she was opened on each side. Organs roughly similar to those described for 1196 were noted. On the right side a strand of tissue was traced posteriorly for a few millimeters but no strand could be identified on the left. No trace of anything resembling normal ovarian tissue was found. As the location of the incision was unfavorable for finding the oviduct, this was not attempted. A bit of each of the organs were removed and sectioned. The histological findings were like those described below.

A short time after the operation it was noted that the new saddle feathers that came in were male-like in that they were fairly long, and laced with bright yellow, though rather bluntly pointed at the end and the central stipe though nearly black was often sprinkled with brown to a greater degree than usual for a male. The feathers of the tail coverts particularly contained much brown. In the breast feathers, less change was noticeable, most of the feathers remaining deep reddish salmon though some of the feathers contained some black. Other parts of the bird showed feathers much like those of the female type.

The third instance is that of a bird hatched June 22, 1913, and castrated August 8, 1913. The juvenile female plumage was well developed at the time. By early winter, however, this plumage had given place to one nearly or quite identical with that of the young male. The spurs developed fully but the comb never became really male-like, but had rather the general appearance of a Leghorn female's comb when straightened up. This comb, however, never loped but was always erect, an exception not at all rare among Leghorn females. It was anticipated that when the bird moulted during the summer

the full male plumage would be assumed. Instead, a different type appeared. The feathers were shaped like those of the hen, except the tail coverts which in shape resembled those of an English Campine male. That is, they were rather longer than those of the hen, curved, and with rounded ends. The dorsal feathers were dull black with golden shafts, sometimes with a few minute brown spots on the margins. Ventrally the feathers were black.

With the moult of 1915, a further change took place in that the breast feathers were replaced with salmon-colored feathers, while there was some increase in amount of brown stippling dorsally, so that this bird, too, was very much like a female. She was opened on each side in October, 1915. The same set of organs was found as described for the preceding instances. This bird, like 3840, also changed the character of its plumage after the operation. The new breast feathers were black, while the saddle feathers were good male though not as long and pointed as is usually the case.

A fourth instance has a history somewhat different from the one just preceding, although it was a litter sister and castrated at the same time. The castration, however, proved to be incomplete in that regeneration of the ovary took place. A minute bit of the ovary must have been left and when it became sufficiently large the new feathers that developed under its influence were female. Nearly a year after the first operation, a second was made and an attempt made to remove the regenerated ovary. Apparently it was successful for the bird soon after began again to assume male characters. The spurs became long but the comb has always remained hen-like, though erect. The present plumage is a mixture of male and female characters. The breast feathers are almost black but contain a little salmon in small patches. The dorsal feathers are not much longer, if any, than those of the normal female but they are triangular at the apex and have a margin of golden bristles. The centers, however, are *female* colored. An examination of the right side in October, 1915, showed a body similar to those described but rather larger. The left side seen from the right appeared to be empty but when an attempt was made to open the bird on the left side, un-

expected difficulties were met, so that it was deemed desirable to proceed no further.

There remain two other birds to be considered. Though both were of hybrid origin their plumage was that of a typical Brown Leghorn. At the time they were castrated, the female juvenile plumage was well developed. After castration both developed spurs and a perfect male coat of plumage but their combs remained small.

Number 4290 was killed November 25, 1914. The same sort of organs on the site of the gonads were noted again. The other, 4471, is still alive and in *perfect male plumage*. In the summer of 1913, a female-like plumage developed, followed in the fall by a return to the male plumage. In 1915 no change in plumage color took place. When opened, October 11, 1915, the same sort of organs were found. Thus, in all but possibly one instance there has been a development of glandular material on *both* sides. The exception relates to the individual that was examined on only one side. It seems probable that though numbers 3840 and 2087 were operated on just prior to their return to the male condition the operation as such had nothing to do with the results secured but rather that a change to this plumage would have taken place as in the case of 4471. It is of course possible that the operations accelerated a change about to take place. It is quite possible, too, that the changes in plumage are cyclic in nature, like the occurrence of the summer plumage in the normal drake.

Because it is desired to keep the birds alive for further observations, the structure of the organs cannot at present be given in detail. It was thought at first that a small piece would suffice for a determination of its structure, but the material thus far examined indicates that the study will have to be made from the standpoint of the organ as a whole. Owing to lack of material, this cannot be attempted for some time to come. However, the material on hand is sufficient to indicate something of its nature. The following description is provisional: The histological findings vary from specimen to specimen and also in different parts of tissue from the same bird. The differences, however, are probably to be referred to developmental stages,

though this is by no means certain. In what is supposed to be the early stages, the cells are small with relatively little protoplasm and closely packed. There is a very weak development of connective tissue which separates the cells into poorly defined groups. Intermediate stages can be found in which the groups of cells become well defined. After the first stage, there is a considerable increase in the connective tissue which in some instances appears to produce smooth, refractive rods or strands. Stages have been noted in which the central cells separate somewhat after the manner of thyroid tissue and stain less readily. These appear to be degenerating. Later the marginal cells also break down so that small open spaces may be found lined mostly by connective tissue. They in turn appear to coalesce by the breaking down of neighboring walls, so that large open spaces appear in the tissue, perhaps homologous with the vesicles filled with a straw-colored fluid observed macroscopically in some instances. In one part of the organ a group of tubules lined with a single layer of square cells has been noted. These appear to be of a different character from the spaces described above. They may contain a finely granular but otherwise amorphic substance.

It is rather probable that the present organ is the result of a development of the Wolfian body. This view, however, is merely a working hypothesis.

Should further investigation confirm this view, it may throw light on the structures described by various observers in cock-feathered females. These bodies are very likely identical with the bodies found in castrated females. Certainly the presence of true seminal tubules or spermatozoa together with ova must be demonstrated before similar individuals found in nature containing these organs can be designated as hermaphrodites.

An explanation of the plumage changes is mainly a matter of surmise. At first, one is inclined to lay the changes at the door of the new organ but since they do not appear in all individuals which have developed the organs, it is evident that if the organs are concerned with the changes there must be some change in the activities of the organs either preceding the changes in plumage or accompanying them.

Among ducks it has been noted that a similar change in plumage is associated with the testes in the *male*, although the organs described have not been found in several castrated female ducks which have been examined. The *ovariotomized* duck may or may not undergo a change in plumage, corresponding to that of the male. Those that undergo such a change have returned in due course of time to the breeding plumage. Thus their temporary plumage is like that of the summer plumage of the male.

The change of plumage in the ovariotomized fowl may be due to the release of a mechanism for changing the plumage but which has been hidden or rendered latent in some way during the phylogeny of the race or as a result of domestication. In this connection it may be noted that laying hens give evidence of a summer moult. This moult is rarely complete and is evidenced usually by the shedding of a comparatively small number of feathers.